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Iodine Status, Thyroid Function, Ferritin Status, And Heavy Metal Distribution In Peripheral Endemic Area of Iodine Deficiency Disorder in Ponorogo District, East Java, Indonesia

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Abstract.

The previous investigation was reported in an area with mental retardation due to iodine deficiency disorders (IDD) in Ponorogo. Low iodine intake, heavy metal contamination, goitrogenic consumption, and low iron intake might play a role in mental retardation incident. The aim of study was to investigate iodine status, heavy metal contamination, and iron status of population in endemic area of IDD area in Ponorogo. About 118 childbearing women age (CBW), 124 school-aged children 9-11 years old (SAC) and 123 children under five (CUF) from Dayakan and Watubonang Village, Ponorogo were selected as sample. Spot urinary iodine excretion (UIC), thyroid stimulating hormone (TSH) and free-tetraiodothyronin, and ferritin serum concentration of the sample were measured. About 29 soil and 87 water samples were taken from both village to measure iodine, mercury (Hg) and lead (Pb) concentration. Median UIC of CBW and SAC were 105 and 121.5ug/L, respectively. Hypothyroid in CBW, SAC and CUF in Dayakan 38.1%; 27.9%; 17.9% and Watubonang 7.3%; 14.3%; 17.9%, respectively. That respondents with ferritin deficiency were 25.8% in Dayakan Village, and 19.8% in Watubonang Village. Mean of iodine concentration in soil and water were 36.74mg/Kg and 13.6ug/L respectively. Mean of Hg soil was 96.46mg/kg and <1ppb in water both areas. Mean of Pb in soil was 5.81mg/Kg, while not detected in water in both area. The IDD and anemia control program should be undertaken to prevent future public health problem in both areas.

Keywords: Iodine, IDD, UIC, heavy metal, goitrogenic

1. Introduction

Iodine deficiency is one of major global public health problem. Wide range of negative impacts resulting from iodine deficiency on human growth events from the beginning of life in the womb to adulthood called Iodine Deficiency Disorders (IDD).

In fetus, IDD might cause abortion, birth-death, congenital abnormalities, increased perinatal mortality and child mortality. In women of childbearing age, IDD can manifest clinically in the form of goiter, hypothyroidism, and impaired mental function. While in toddlers and school children, iodine deficiency is known to cause hypothyroidism, impaired growth and decreased intellectual capacity. A number of studies comparing the school children, who lived in endemic and non-endemic area of IDD, showed that children who lived in endemic areas had lower levels of cognitive development and school achievement. In general, the impact of iodine deficiency is mental retardation, which in turn has an impact on social and economic development of the country (Zimmermann, 2007; Djokomoeljanto, 1986). Epidemiological observations suggest that environmental factors have a significant effect on the settlement and development of new IDD cases in endemic areas (Hetzel and Dunn, 1989).

Low iodine content of the environment is a main cause of IDD. Iodine content of the soil is specific for its environment. Ecological processes has eliminated iodine in many regions through flooding and exacerbated by heavy rains. Mountain areas and flood plains generally contain low iodine. Food produced in an iodine lack environment would not be able to provide enough iodine for human needs. Similarly, water from iodine lack environment might contain low iodine. Theoretically, in the mountainous areas might found IDD case, generally. However, IDD was also found in coastal areas and islands, where the materials goitrogenik, blocking agents, and genetic factors apparently played a role in these conditions (Taha and Dahlan, 2002; Sulchan, 2007; Zimmermann, 2015).

Land management that was not in accordance with the principles of green industry might indirectly affect the GAKI problem through the loss of iodine from the environment. Loss of environmental iodine often occurs anthropogenically in areas due to loss of vegetation from clearing for agricultural production, overgrazing by livestock and tree-cutting for firewood, ensures a continued and increasing loss of iodine from the soil (Karmarkar et al., 2003).

The presence of heavy metals in the environment in many cases was related to the incidence of endemic goiter. Drinking water from shallow water is often contaminated by heavy metals. Heavy metals are known to inhibit the use of iodine in the thyroid gland (Sulchan, 2007). Iron deficiency exacerbates the effects of iodine deficiency. Iron deficiency reduces heme-dependent thyroperoxidase activity in the thyroid and impairs production of thyroid hormone. In goitrous children, iron deficiency anemia blunts the efficacy of iodine prophylaxis while iron supplementation improves the efficacy of iodized oil and iodized salt. (Zimmermann, 2007).

Figure 1. Location of Ponorogo Regency

Ponorogo is regency (kabupaten) in East Java Indonesia. Ponorogo regency lies between 92 and 2,563 meters above sea level and covers an area of about 1,305.7 km2. The previous investigation showed that Ponorogo had problem of IDD. In 1998, Total Goiter Rate (TGR) among school children was 23.6 % ; with the range 3.3 % to 60.1 % in all district (WHO, 2001). Based on Muftiana and Munawaroh (2016), at least 400 residents who experience idiots or mental retardation in Ponorogo Regency. The reason of it was the lack of iodine consumed by population. The aim of study was to investigate iodine status both in population and in environment, heavy metal contamination, and iron status of population in endemic area of IDD area in Ponorogo.

2. Method

This research is a descriptive study with cross-sectional design. About 118 childbearing women age (CBW), 124 school-aged children 9-11 years old (SAC) and 123 children under five (CUF) from Dayakan and Watubonang Village, Ponorogo were selected as sample. About 50 mL urine from CBW and SAC were taken and measured of its iodine concentration through spectrophotometric method by Sandell Kholthoff reaction principle. About 5 mL blood were taken from CBW and SAC for thyroid stimulating hormone (TSH) and free-tetraiodothyronin (fT4), and ferritin serum concentration measurement throuh ELISA (enzyme-linked immunosorbent assay). For CUF, only fT4 were measured from blood sample that were taken through same way with CBW and SAC. All measured were conduct in Iodine Deficiency Disorders Research and Development Center Magelang. Soil samples from 29 point samples and water samples from 87 water sources were collected and measured concentration of iodine and mercury (Hg) and lead (Pb) of each sample through Atomic Absorption Spectrophotometry (AAS) method in Integrated Research and Testing Laboratory (Laboratorium Penelitian dan Pengujian Terpadu, LPPT) Gadjah Mada University and Center for Environmental Health Engineering and Disease

Control (Balai Besar Teknik Kesehatan Lingkungan dan Pengendalian Penyakit, BBTKLPP) Yogyakarta.

3. Result

3.1. Iodine Status

Overall percentage of UIC less than 100 ug/L in CBW was 44.9 % and median 105 ug/L; and UIC in SAC was 33.9 % and median 121 ug/L. In Dayakan Village UIC less than 100 ug/L in CBW was 46.0 % and median 106 ug/L; and UIC in SAC was 35.3 % and median 119 ug/L. In Watubonang Village UIC less than 100 ug/L in CBW was 43.6 % and median 105 ug/L; and UIC in SAC was 32.1 % and median 127 ug/L (Table 1).

There were no population in this two villages with percentage of UIC less than 100 ug/L less than 50 % and median UIC less than 100 ug/L both in CBW and SAC. It showed that population both in Dayakan and Watubonang had no iodine deficiency based on World Health Organization criteria.

Table 1: Percentage and Median Urinary Iodine Excretion (UIC) in Dayakan and Watubonang

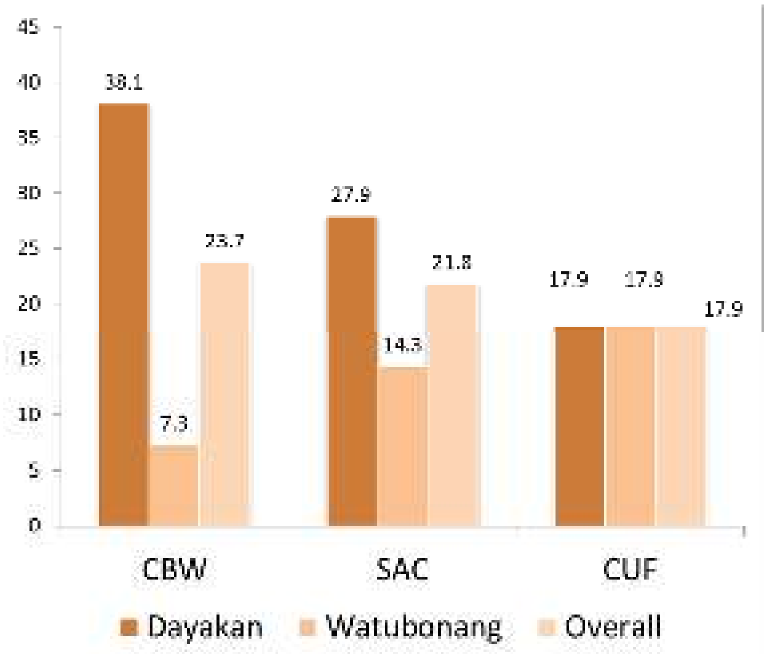
Area/Population	Percentage of UIC			Median UIC
	<100ug/L	100-199ug/L	>200ug/L	
Dayakan Village				
Childbearing Women Age (CBW)	46.0 %	41.3 %	12.7 %	106 ug/L
School Age Children (SAC)	35.3 %	42.6 %	22.1 %	119 ug/L
Watubonang Village				
Childbearing Women Age (CBW)	43.6 %	45.5 %	10.9 %	105 ug/L
School Age Children (SAC)	32.1 %	51.8 %	16.1 %	127 ug/L
Overall				
Childbearing Women Age (CBW)	44.9 %	43.2 %	11.9 %	105 ug/L
School Age Children (SAC)	33.9 %	46.8 %	19.4 %	121 ug/L

Note: In children and non-pregnant women, median urinary iodine concentrations of between 100 µg/l and 299 µg/l define a population which has no iodine deficiency, when the median is 100 µg/l, at least 50% of the samples will be lower than 100 µg/l (WHO, 2007).

3.2. Thyroid Status

Hypothyroidism was found in CBW, SAC, and CUF both in Dayakan and Watubonang Village. Hypothyroidism percentage in Dayakan in CBW was 38.1 % and SAC was 27.9 %. Percentage of hypothyroidism in Watubonang Village in CBW was 7.3 % and in SAC was 14.3 %. Hypothyroidism in CUV was in the same condition both in Dayakan Village and Watubonang Village was 17.9 %. Overall in Dayakan and Watubonang Village, hypothyroidism percentage in CBW was 23,7 %, in SAC was 21.8 %, and CUV was 17.9 % (Figure 2).

Figure 2: Hypothyroidism in CBW, SAC and CUF in Dayakan and Watubonang (%)



3.3. Ferritin Status

Both population in Dayakan and Watubonang Village had ferritin deficient. Overall, 23.0 % respondent had ferritin deficiency. About 25.8 % and 19.8 % respondents in Dayakan and Watubonang, respectively, had ferritin deficiency (Table 2).

Table 2: Ferritin Status in Dayakan and Watubonang

Area	Percentage of Ferritin Status	
	Normal	Deficient
Dayakan Village	74.2 %	25.8 %
Watubonang Village	80.2 %	19.8 %
Overall	77.0 %	23.0 %

3.4. Iodine in Water and Soil

It was detected wide range of iodine concentration in water and soil in Dayakan and Watubonang Village. Overall iodine concentration in water range between 0-49 ug/L and median 8.5 ug/L. Iodine concentration in water from Watubonang Village ranged between 2-49 ug/L with median 16.0, and in Dayakan Village where iodine concentration ranged between 0.0-5.0 ug/L with median 0.0 ug/L. Soil iodine concentration ranged between 6.6-108.0 ug/L and median 33.77 ug/L. Soil iodine concentration in Watubonang Village ranged between 51.96 mg/Kg, and in Dayakan Village ranged between 6.6-108.0 mg/Kg and median 17.41 mg/Kg (Table 3).

Table 3: Iodine Concentration in Water and Soil in Dayakan and Watubonang Village

Iodine Concentration	Dayakan	Watubonang	Overall
- Water	0.0 ug/L (0.0-5.0)	16.0 ug/L (2-49)	8.5 ug/L (0-49)
- Soil	17.41 mg/Kg (6.6-108.0)	51.96 mg/Kg (33.7-100.2)	33.77 mg/Kg (6.6-108)

3.5. Lead (Pb) and Mercury (Hg) in Water and Soil

It was detected mercury in water in these two village, it ranged between 0.0-23.24 ppb and median 0.0 ppb. In Dayakan Village, mercury concentration ranged between 0.0-4.91 ppb and median 0.28 ppb and it was higher than in Watubonang Village with mercury concentration 0.0-23.24 ppb and median 0.0 ppb. In soil, mercury concentration in Dayakan Village ranged between 7.43-296.4 mg/Kg and median 71.79 ppb, and it was higher than in Watubonang Village where it ranged between 21.15-462.05 and median 63.32 ppb (Table 4).

Lead concentration in water was not detected both in Watubonang and Dayakan Villages. In soil, lead was detected up to 25.23 mg/Kg and median 3.27 mg/Kg overall. In Dayakan Village, lead in soil was detected in concentration up to 25.23 mg/Kg and median 2.61 mg/Kg, while in Watubonang Village range from 21.15 to 562.05 mg/Kg and median 8.90 mg/Kg (Table 4).

Table 4: Iodine Concentration in Water and Soil

	Dayakan	Watubonang	Overall
Mercury (Hg)			
- Water	0.28 ppb (0.0-4.91)	0.0 ppb (0.0-23.24)	0.0 ppb (0.0-23.24)
- Soil	71.79 ppb (7.43-296.4)	63.32 ppb (21.15-562.05)	68.64 ppb (7.43-562.05)
Lead (Pb)			
- Water	0.00 ppm (0.00-0.00)	0.00 ppm (0.00-0.00)	0.00 ppm (0.00-0.00)
- Soil	2.61 mg/Kg (0.00-25.23)	8.90 mg/Kg (2.97-19.54)	3.27mg/Kg (0.00-25.23)

4. Discussion

Ponorogo Regency is an endemic goiter area. Various studies related to child growth and development show that various growth and development disorders that occur in Ponorogo Regency are related to iodine intake deficiency. Efforts to intensify the management of IDD that have been carried out since the 1990s have shown improvements in iodine intake, including in Ponorogo District. This is illustrated from the results of this study which showed that iodine intake in the two target villages had no iodine deficiency. However, adequate iodine intake alone cannot guarantee normal thyroid function which produces sufficient thyroid hormone. Hypothyroidism found in school-age children, women of childbearing age, or toddlers in this study showed that there are other factors besides iodine as a cause of thyroid dysfunction in addition to lack of iodine intake.

The low environmental iodine in Ponorogo is a fundamental enabling condition causing IDD problems in the past, as in general. However, this condition may be exacerbated by the presence of pollutants in the form of heavy metals identified in drinking water and soil. Although detected in very low concentrations, but because of exposure in a long time it will cause an accumulative effect in the form of disruption of iodine metabolism in the synthesis of thyroid hormones. Contamination of heavy metals in children during growth and development both during the womb or in the first years of life has a more severe impact. Heavy metal contamination can reach population via digest contaminated drinking water and food and heavy metal dust complex inhalation. The problem of iron nutrient anemia found in Ponorogo Regency identified in this study through ferritin, deficiency can also be a condition that aggravates the problem of IDD. Iron nutrient anemia causes iodine metabolism to be suboptimal. In children lacking iodine intake, iron nutrient anemia inhibits the effects of iodine supplementation thereby inhibiting the elimination of the impact of IDD.

In endemic areas, IDD is very likely to return due to the low availability of environmental iodine, such as in Ponorogo Regency. Therefore, prevention efforts need to be continued either through iodine intervention through the distribution of iodized salt and to avoid other factors that can exacerbate or prevent the success of the intervention. The implementation of iodized salt program for all, efforts to meet the needs of iron and community sanitation related to the quality of drinking water need to be improved to ensure the continuity of community iodine adequacy and prevent the emergence of IDD in the community.

It is frequently said that the nations that have succeeded in bringing iodine and iron deficiency under control did so with less knowledge and technology than is available today. But those nations usually had the advantages of higher incomes, better diets, and more developed health services. Industrialisation and development will generally lead to the improved nutritional status of a population including iodine and iron status due to foodstuffs originating from outside the local environment. As the production of manufactured food increases there will also be more sources of adventitious iodine and iron in the diet. That was iodine added to food but not for the purpose of iodine supplementation. There were many adventitious sources of iodine in the diet in industrial cultures including iodine content of poultry and eggs increased by the use of fish flour as chicken food, iodoform used in water as a disinfectant, iodates used as oxidants and sanitising agent in the bread making process, use of iodophors as antiseptic cleansing agent in the dairy industry, and iodine-rich red food colouring erythrosine. In agriculture several I-containing herbicides and fungicides release iodine to soil as they decompose. Commercial products were regularly fortified with iron. The fortification of cereal products with iron and ascorbic acid is important in meeting the high dietary needs, especially considering the importance of an optimal iron nutrititure during this phase of brain development.

Agricultural practices through the implementation of green industry concepts further guarantee the conservation of iodine in nature and the quality of water in the environment. The erosion prevention of soils in riverine areas due to loss of vegetation from clearing for agricultural production, overgrazing by livestock and tree-cutting for firewood, ensures a preventing loss of iodine from the soil, then ultimately determines iodine levels in foodstuffs of local products. Protection of surface and groundwater pollution need to be done for unpolluted drinking water that was need to healthier life including thyroid function.

Surveillance of IDD need to be done to track emerging IDD-related issues at an early stage and find active solutions in a timely manner. Continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice including in IDD elimination. Industry 4.0 offers technology with computer involvement and automation that encourages interoperability, data transparency, technical assistance, and decentralized decision making. The application of industry 4.0 concepts in the surveillance system will support effective decision making in the handling of IDD.

5. Conclusion

Overall, thyroid function disorder was still found in Ponorogo Regency despite iodine status of population showed in normal value. Heavy metal contamination and iron deficiency in population might cause thyroid disfunction. Iodine intervention in Ponorogo district must continue to be carried out supported by efforts to overcome iron malnutrition and improve sanitation, especially the supply of water that is free of heavy metals.

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